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# THE WORK OF DREYER IN RELATION TO LIFE INSURANCE EXAMINATIONS[1]

By Louis I. Dublin, *Metropolitan Life Insurance Company*

The subject, "The Assessment of Physical Fitness," commends itself especially to an audience of life insurance medical directors. For to assess physical fitness of applicants for insurance is exactly their function. One could hardly have hit upon a more apt title than has Dr. Georges Dreyer, of Oxford, for his recent book. When you pass upon an applicant for insurance, you assess his physical fitness on the basis of his structural and functional normality. You look for sound heart, lungs, and kidneys, for sound mind, and for evidence of normal health in the applicant's appearance and his ability to carry on his daily work. Recently, you have turned to such supplementary evidence of physical fitness as that afforded by the interrelationship of height and weight according to age. There are, of course, other items, such as occupation, habits, and the living conditions of the applicant, which assist in forming a judgment of what constitutes a standard risk. Your basic assumption is that every one of the points referred to has a definite and measurable effect on longevity, and that in their totality they give a fairly good guide for classifying applicants into those who will and those who will not measure up to the expectation of the mortality tables used as a basis for the calculation of premiums.

Dr. Dreyer is not concerned with life insurance examinations. He is interested primarily in developing a series of norms for distinguishing those who are physically fit from those who are not. These norms are based on the interrelationships existing between a limited number of bodily measurements, which are as follows: weight, height sitting or stem length, and circumference of chest and vital capacity as measured by the spirometer. These measurements, which are easily made, Dreyer believes give a clue to physical fitness. He has discovered, he says, the true relationships which exist between these four measurements in the healthy individual. By actually applying the normal relationships to individual cases, he thinks he can distinguish those who are physically fit from those who are not.

Dreyer expresses the relationships between the four measurements referred to in a series of simple formulas. Each one of these gives the value of one of the measurements in terms of one of the others. Thus, there are formulas which express the relationship between the weight and the stem length, between the weight and the chest girth, between the chest girth and the stem length, and between each one of these three measures and the vital capacity. These six formulas are applicable to persons up to age 50. There is a set for males and one for females, the two sexes being very different in the interrelationship of their measurements. To obviate calculations, the author in his book has appended a number of tables which express the values of these measurements in terms of each other. Thus, for each stem length in centimeters, a table gives the corresponding weight in kilograms; another table gives the weight corresponding to chest girth. It is possible from the tables to read off what all the measurements of a normal individual should be from any one of the four that may be given. There are two sets of tables for both males and females, one in the metric system, the other in the American or English system of weights and measures.

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[1] Read at the Annual Meeting of the Association of Life Insurance Medical Directors, October 20, 1921.

The writer desires to express his obligation to Professor C. C. Grove and Miss Margaret E. Gantt, of the Statistical Bureau, for their valuable assistance in the preparation of this paper.

Dreyer presents a number of apt illustrations which show concretely the uses of his tables. The problem is to determine whether or not an individual is physically fit according to his actual measurements. Given the four measurements, he finds first the expected weight from the stem length and also from the chest measurement. If these agree with the actual weight, the person has normal proportions. But in many instances he finds normal persons whose theoretical weights according to stem length and according to chest girth are different. In such cases he takes the average of the two theoretical weights and compares that average with the actual weight to determine the individual's fitness. If the individual has a normal weight, he then finds the theoretical vital capacity from the actual weight. He compares that figure with the actual vital capacity to determine the percentage deviation from the theoretical vital capacity. If an individual has a weight which is 5 per cent from the normal, he possibly has an abnormal weight; if he differs from the normal by as much as 10 per cent, he is probably abnormal with respect to weight; and if the deviation reaches as much as 15 per cent, his weight is certainly abnormal. Individuals may be abnormal as to weight and still be physically fit. If they are overweight and their vital capacity is commensurate with their added weight, they are considered physically fit because they have a larger vital capacity than would be expected from their stem length and chest. On the other hand, persons who are underweight for their stem length and chest may be physically fit if their vital capacity is commensurate with their stem length and chest. The following are two illustrations, the one being taken from Dreyer's examples of a person who is normal in all respects, and the other improvised to illustrate a person who is physically unfit according to the Dreyer standards:

### ILLUSTRATION 1[1]

Female, age 21 years

Observations

Weight of body = 62.0 kilograms
Length of trunk = 88.8 centimetres
Circumference of chest = 75.0 centimetres
Vital capacity = 3,630 cubic centimetres

Calculation

Weight derived from length of trunk (88.8 cm.) = 64.71 kilos (from Table VII).

Weight derived from circumference of chest (75.0 cm.) = 59.16 kilos (from Table VIII).

Averaging $\frac{64.71+59.16}{2}=61.9$ kilos, which is the normal weight corresponding to the observed length of trunk and circumference of chest.

Subtracting the calculated weight from the observed weight,

$$62.0-61.9=+0.1 \text{ kilos}$$
$$\frac{+0.1\times 100}{61.9}=+0.2\% \text{ (or roughly } 0\%).$$

Therefore the person weighs exactly what she should weigh according to the tables.

Since by the above calculation the person's weight is found to be normal, the vital capacity as calculated from the observed weight will be correct; therefore:

Vital capacity derived from weight of the body (62.0 kilos) = 3,556 cc. (from Table X, Class A).

Subtracting the calculated from the observed vital capacity,

$$3{,}630-3{,}556=+74 \text{ cc.}$$
$$\frac{+74\times 100}{3{,}556}=+2.08\% \text{ (or roughly } +2\%).$$

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[1] Taken from Georges Dreyer and George F. Hanson, *The Assessment of Physical Fitness*, American ed., Paul B. Hoeber, New York, 1921, p. 109.

Therefore the person has 2 per cent greater vital capacity than she should have according to the tables for Class A, calculated from the weight of the body.

### ILLUSTRATION 2

Male, age 25 years

Observations

Weight of body = 121 lb. 3 oz.
Length of trunk = $34\frac{7}{8}$ inches
Circumference of chest = $33\frac{1}{2}$ inches
Vital capacity = 3,272 ccm.

Calculation

Weight from stem length = 135.35 lb.
Weight from circumference of chest = 137.99 lb.
Averaging above weights = 136.67
$\therefore$ Person is 11.3 per cent underweight.

The vital capacity if obtained from the actual weight would be too low for the stem length and the chest girth. We therefore calculate the vital capacity from the stem length and the circumference of chest as follows:

Vital capacity from stem length = 4,061 cc.
Vital capacity from chest circumference = 4,118 cc.

The average is 4,090 cc.

The actual vital capacity is 20 per cent below normal by stem length and chest circumference.

This individual is, therefore, not in physically fit condition according to Dreyer.

These two illustrations show how Dreyer's tables may be used to discover individuals who are physically fit or are abnormal according to his standards. He is particularly convinced of the value of the vital capacity as an index of physique and health. By applying his values for vital capacity to the measurements of a large number of tuberculous patients, he has been able to determine the stage of tuberculosis, to give the prognosis in these cases, and to indicate the benefit derived from sanatorium treatment. He believes that his measures disclose the existence not only of tuberculosis but of other diseases as well. This phase of the work has been confirmed by a number of other observers for cases of tuberculosis and of heart disease.

Obviously, a work which promises to do all of this should be of the greatest interest to life insurance executives. For if we can through a series of simple measures really distinguish the fit from the unfit, we have made an important advance. But before we can accept as demonstrated so epoch-making a contribution we must be very sure that the premises are correct and that the conclusions are sound. Let us then see how nearly the conclusions of Dreyer are justified by the internal evidence presented, and to what extent the conclusions can be applied to the life insurance business. To evaluate the work of Dreyer it is necessary not only to read his book but to study very carefully a number of highly technical papers which he has issued from time to time. The most important of these papers appeared in the *Lancet*, August 9, 1919, and was entitled, "The Normal Vital Capacity in Man and Its Relation to the Size of the Body." In this paper he derives the various formulas which express the relationships existing between the four measurements already referred to. The relationships are worked out from the measurements of 16 males who ranged in age from 13 to 52 years and were selected for their physical fitness.

Strangely enough, Dreyer does not use the same formulas in his book as in his *Lancet* paper. The following parallel columns will show the differences:

COMPARISON OF FORMULAS FOR VARIOUS MEASUREMENTS FOR MALES[1]

[1] $W$=weight in grammes; $\lambda$=length of trunk in centimetres; $Ch$=circumference of chest in centimetres; $VC$=vital capacity in cubic centimetres.

| | Book | *Lancet* paper |
|---|---|---|
| (1) | $W=.38025\sqrt[.319]{\lambda}$ | $\lambda=\frac{W^{\frac{1}{3}}}{.449}$ or $W=.0905\sqrt[.33]{\lambda}$ |
| (2) | $W=.662\sqrt[.365]{Ch}$ | $Ch=\frac{W^{\frac{1}{3}}}{.457}$ or $W=.0954\sqrt[.33]{Ch}$ |
| (3) | $Ch=\frac{\lambda^{1.1442}}{2.00148}$ | not given |
| (4) | $VC=\frac{W^{.72}}{.69}$ | $VC=\frac{W^{.72}}{.69}$ |
| (5) | $VC=\frac{\lambda^{2.257}}{6.1172}$ | $VC=\frac{\lambda^{2}}{1.9}$ |
| (6) | $VC=\frac{Ch^{1.973}}{1.5595}$ | $VC=\frac{Ch^{2}}{1.82}$ |

Formulas (1) and (2) for males as given in the book are very unlike those in the *Lancet* paper. They are, moreover, not the ones from which the tables in the book were computed. As might be expected, they are not consistent with the other formulas. Number (1) should read $W = .0483\sqrt[.319]{\lambda}$, and number (2) should read $W = .3229\sqrt[.365]{Ch}$. With these corrections, the six formulas of the two series agree very closely even if they do not appear to on first inspection. There are similar discrepancies in the formulas presented for females. $W = .36093\sqrt[.313]{\lambda}$ should read $W = .03856\sqrt[.313]{\lambda}$, and $W = .30213\sqrt[.284]{Ch}$ should be $.01478\sqrt[.284]{Ch}$. Otherwise the formulas are consistent and are used in compiling the tables. It is difficult to understand how these errors have crept into the book. But they are there.

Let us now consider the set of formulas as corrected. Do they truly express the relationship between the various measurements that we are considering? To answer this question we attempted to derive the formulas independently. By the method of least squares we obtained a series of values which fitted the facts pretty well but which did not present so close a fit as the values obtained by Dreyer. We did not exactly duplicate any of the Dreyer formulas, although we could approximate a number of them on theoretical grounds. It must be admitted that his formulas fit the data for the 16 males better than any other values we could obtain. Let us examine some of these formulas separately.

$$VC = \frac{W^{0.72}}{0.69}$$

This formula is the most important in the series. On applying it to each one of the 16 individuals, we found only one whose actual vital capacity deviated considerably (+6.7%) from that predicted by the formula. But in view of the fact that an excess of vital capacity is a favorable feature, no fault can be found with the fit of the formula to these individuals. Similarly, Dreyer applied this formula to the material of Schuster, and he shows that the relationship between weight and vital capacity in this large group of Oxford undergraduates as a whole is in accordance with the formula.

We have in like manner attempted to apply this Dreyer formula to a group of Harvard undergraduates[1] and have found that these boys, with few exceptions, had a higher vital capacity than that predicted by the formula according to their weights. This finding does not in itself impair the value of the formula, because, as Dreyer says, the vital capacities he has given are averages for fit individuals and may be exceeded by highly developed and athletic persons.

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[1] West, "Clinical Studies on the Respiration," Arch. of Int. Med., vol. 25, p. 306.

His other formulas are not quite so fortunate. Let us take the one expressing vital capacity in terms of stem length. The formula is:

$$VC = \frac{\lambda^2}{1.9} \text{ or } \frac{\lambda^{2.257}}{6.1172}.$$

When applied to his 16 individuals, we find that one person, No. 12, has a vital capacity which is 20 per cent in excess of that predicted, whereas No. 16 is 13 per cent below. There are altogether 6 individuals whose vital capacity is at least 7.85 per cent above or below the normal. If we use the formula given above (used in his book) we find that there are 6 individuals whose vital capacity is at least 6 per cent above or below the expected. These are presumably fit persons, and since there are 2 individuals out of 16 who are seriously below the expectation, it would seem either that there is something wrong with the formula as an expression of fitness or that there are wide limits between which fit individuals can be found. These deviations from normal vital capacity are almost as marked as are those calculated from height standing according to Hutchinson's method, which Dreyer insists has no value.

Nevertheless he places great confidence in this expression for vital capacity and height sitting and prefers it even to the previous formula showing vital capacity in relation to weight, because, as he points out, weight may change rapidly but stem length does not.

Likewise his formula for vital capacity and chest,

$$VC = \frac{Ch^2}{1.82} \text{ or } \frac{Ch^{1.973}}{1.5595},$$

shows a considerable range of deviation for his 16 individuals. There are 5 persons in his series who are all the way from 6 to 10 per cent below the expected vital capacity. Yet he insists that the vital capacity of fit persons must not fall so much as 10 per cent below the normal. Following out his own procedure we averaged the calculated vital capacities as obtained from both stem length and from chest. We found by this method that of the 16 persons specially chosen for their physical fitness, 3 had a vital capacity 7 per cent or more below the normal. One of these, No. 16, is 8.8 per cent below, which is close to the limit for "probably" unfit individuals according to Dreyer's standards. This same individual is 7.7 per cent underweight for his stem length and chest girth, and 3.1 per cent under vital capacity even for his underweight.

There is another line of evidence that all is not well with these formulas. Take, for example, the relation between weight and stem length and weight and chest. Dreyer, equating the two formulas, concludes that "in the normal healthy man the circumference of the chest is, on the average, about 1.5 per cent smaller than the stem length, though in a fair number of the individual cases the chest measurement may be greater than the stem length." On applying this test to his own series we find that 4 out of the 16 individuals have chest girths 4.5 to 6.2 per cent greater than their stem length, and 4 more have chest girths from 5.5 to 10.1 per cent less than their stem length. There is, obviously, too much variation to satisfy the rigid expressions laid down by Dreyer. The conclusion drawn from these several discrepancies is that Dreyer attaches more value to his formulas than is justified by the facts. The proper relationship between the several measures must be expressed in terms of a measure of correlation with limits between which the variables may fluctuate.

So far we have referred to the formulas for males only. One half of Dreyer's book is given over to tables for females which show the relationships existing between the four measurements heretofore discussed. These tables are constructed on the basis of formulas similar to those for males. But nowhere does Dreyer give us any clue as to how these formulas were obtained, how many lives they were based upon, and whether they have been confirmed by others. In fact, they are interjected into the book without any explanation. I have already called your attention to errors in the two basic formulas for weight in terms of stem length and chest. But even a very cursory examination of the tables and the formulas shows that they are inconsistent with some of the well-known facts with reference to the relation of build of women to that of men. For example, Dreyer's tables show that for the same stem length or height sitting, women are heavier than men. For a height sitting of 35 inches, a male according to Dreyer should weigh 137 pounds and a female, 143 pounds; that is, a female is about 5 per cent heavier. But we know that for the same height standing, females are a little lighter than males. The anthropologists tell us that females have a relatively greater height sitting than males. Therefore it would follow that for the same height standing, females would be lighter according to our standard tables of height and weight, whereas they would have longer stem lengths and, therefore, appreciably greater weight than the males according to the Dreyer tables which are correct. The discrepancy is really very considerable, and I am inclined to say that for the present at least no use can be made of that section of Dreyer's book which relates to females.

The important question for us today is what use we can make of the Dreyer work. I will say frankly that as yet its use is very limited.

The Dreyer researches are still in an experimental stage. We should hesitate to apply to practical business affairs standards which are likely to be greatly changed when derived from the measurements of larger groups of people whose physical condition is more definitely known than was the physical condition of the group reported upon by Dreyer.

But quite apart from the accuracy of the formulas, there is the fundamental question as to their significance. Dreyer insists that they express the relationship between the various measurements in physically fit people, and that they can be used to distinguish between those that are physically fit and those that are not. Unfortunately, this is the weakest spot in the entire work. For what is meant by "physical fitness"? If this is an expression merely of the general vigor of an individual or of individuals as determined by their appearance, then, obviously, there is little value for us in the characterization. We know only too well that individuals of good general appearance may on careful examination be found to be suffering from serious physical defects. If we assume that the 16 persons who made up Dreyer's series and the other groups which also confirm his findings were persons who on actual physical examination were found to be free from organic disease, then we have a better basis. But even then the applicability of the work to insurance must be limited. For in the last analysis the insurance examiner is concerned with fitness in the sense of the ability to live. This is the one test of physical fitness which insurance constantly has in mind. In this sense physical vigor is not the only consideration. Personal history, habits, and a host of other items enter as determinants of longevity. "Physical fitness" and "longevity" are far from synonymous. We know that certain races are notoriously long-lived, but are not physically well developed; that females have greater longevity but poorer physique than males, and that certain occupations, especially where the work is sedentary, lead to the development of poor physique, but do not necessarily involve a short life span for the workers.

It must be clear, therefore, that from the insurance standpoint the Dreyer work is at its inception. What is necessary for us is a series of measures of the Dreyer type which are definitely known to express relationships among individuals who correspond in insurance language to standard lives. We must avoid loose or vague expressions. By standard lives, as opposed to the physically fit, we mean individuals who will give a subsequent mortality corresponding to our usual tables. With reference to Dreyer's fit persons we can say nothing as yet. The problem then resolves itself into tracing the subsequent mortality of various groups of individuals whose relative indexes are known. We shall in that way build up a fund of information which is likely to be very useful to us.

Yet the work is very suggestive, and it would be entirely unfair to leave the impression that there is no utility for us in Dreyer's studies. He has opened up a wide field for further investigation. The most fruitful contribution for insurance purposes is likely to come out of a revision of the indexes giving the relationship between height sitting, chest girth, and weight. We shall have to forego the idea of perfect correlation between these three measurements and attempt rather to find the limits of their variability among standard lives. A series of tables should be prepared showing, for example, the distribution of weights for each inch of height sitting and the mortality experience of each combination. A similar table for chest girth and weight would be needed. Research might show that the best results for insurance work follow from a combination of chest girth and height sitting in relation to weight. Such tables will agree better with the known facts of human variability than do Dreyer's rigid formulas which leave, theoretically at least, little or no room for variation from the type.

The height and weight tables we now use in insurance work illustrate the other extreme, that is, much variability of weight with reference to total height. For the weights for any given height may vary enormously from the average. In height and weight relationships there is a very wide range instead of concentration at the average. Furthermore, mortality is apparently not seriously affected by this extreme range of variability, for individuals may be as much as 30 or even 40 per cent below the average and still enjoy standard mortality. For underweights, at least, our height and weight tables have apparently little value. The coefficient of correlation between total height, weight, and mortality is too low to give useful indexes for insurance purposes.

It is because of this defect in the height and weight tables that Dreyer's alternative measurements for height sitting, chest girth, and weight may prove of the greatest value. These three measurements are much more closely correlated than are height standing and weight. The limits of variability will be found to be much less. It is only necessary to identify the various combinations with the facts of mortality. This has not yet been done. It is the chief suggestion that arises out of the consideration of Dreyer's work. For it is possible that when further investigation is carried out, we shall have guides as to build which will be very much better than the height and weight relationships we now use.

The relationship of vital capacity to weight, although probably the most accurate in the whole series presented by Dreyer, is one which unfortunately is not adapted to the insurance business on a large scale. Spirometer readings can be very much modified through exercise, and it would be entirely possible for an applicant with a low spirometer reading to increase his vital capacity very appreciably through exercise and practice without materially improving his health. Spirometers are rarely, if ever, found in physicians' offices, and the use of this rather expensive instrument must be limited to laboratories. It is conceivable, however, that the method may be useful in clearing up some doubtful cases in which the build of the applicant suggests defects which are not proved on the examination. Take, for example, an applicant who is overweight 30 per cent and who otherwise presents a good picture of physical health. According to present practice we should be suspicious of him, especially if the amount of insurance were considerable. Our practice would be to reject him or to offer him sub-standard plans. But suppose the individual has the predicted weight for his stem length and chest measure and the normal vital capacity for his weight. It is then probable that such a person would prove a much better risk than the applicant who was overweight for his other proportions and whose vital capacity was too low for his extra weight.

It is possible, however, that the relationships between vital capacity and the other measurements may prove useful in singling out cases of incipient tuberculosis. Dreyer's work seems to indicate that there is a much lower vital capacity among persons in that condition. The Dreyer measures might serve as one more guide in forming a judgment on such applicants. In the same way, the Dreyer measures for vital capacity when applied to cases of arrested tuberculosis might very well indicate which were the safest risks.

But the chief value to us in Dreyer's work lies in the future. He has opened up an obviously rich field for further investigation. It may well be that the insurance companies are the best agencies for revising his formulas and for adding to their value. For such units as they will prepare will measure the very definite character of longevity rather than the vague condition of physical fitness. I am inclined to believe that many contributions will be made at the future meetings of this association by members engaged in revising and refining the very fertile work of our author.